Subject: Laser Safety Program Documentation		
Prepared By: Brian Sheehy	**Approved By:** Xijie Wang	**Approved By:** James B. Murphy

BROOKHAVEN NATIONAL LABORATORY
LASER CONTROLLED AREA
STANDARD OPERATING PROCEDURE (SOP)

This document defines the safety management program for the laser system listed below. All American National Standard Institute (ANSI) Hazard Class 3b and 4 laser systems must be documented, reviewed, and approved through use of this form. Each system must be reviewed annually.

System description: Drive and seed laser system for the Deep Ultraviolet Free Electron Laser (DUVFEL)
Location: Source Development Laboratory, Building 729, Clean room enclosure.

LINE MANAGEMENT RESPONSIBILITIES

The Owner/Operator for this laser is listed below. The Owner/Operator is the Line Manager of the system and must ensure that work with this laser conforms to the guidance outlined in this form.

Owner/Operator:		
Name: Brian Sheehy	*Signature:*	*Date:* Oct 1, 2003

AUTHORIZATION

Work with all ANSI Class 3b and 4 laser systems must be planned and documented with this form. Laser system operators must understand and conform to the guidelines contained in this document. This form must be completed, reviewed, and approved before laser operations begin. The following signatures are required.

Chris Weilandics

BNL LSO printed name | *Signature* | *Date*

Andrew Ackerman

ES&H Coordinator printed name | *Signature* | *Date*

APPLICABLE LASER OPERATIONS
x? General Operation x? Alignment x? Service/Repair ? Specific Operation ? Fiber Optics

ANALYZE THE LASER SYSTEM HAZARDS

Hazard analysis requires information about the laser system characteristics and the configuration of the beam distribution system.

LASER SYSTEM CHARACTERISTICS

Laser Type *(Argon, CO2, etc)*	Wavelengths (nm)	ANSI Class	Maximum Power of Energy/Pulse	Pulse Length	Repetition Rate
1 SP* Ti Sapphire	~800	IV	13 nJ	80 femtosecond	80 MHz
2 SP Nd:YVO_4	532	IV	CW, 6 Watts	CW	CW
3 SP GCR-150 Q-switched YAG	532, 1064	IV	320 mJ(532 nm) 1 J (1064 nm)	6 nsec	10 Hz
4 SP GCR-170 Q-switched YAG	532, 1064	IV	450 mJ (532 nm) 1.5 J (1064 nm)	6 nsec	10 Hz
5 Ti:Sapph chirped pulse amplification (CPA) system	~800	IV	35 mJ	0.1-250 psec	10 Hz
6 Nonlinear frequency synthesis from CPA system	260-800	IV	4 mJ	0.1-20 psec	10 Hz
7 Alignment diode laser	780	IIIb	CW .005 Watts	CW	CW
8 Helium Neon lasers	632	IIIb	CW .030 Watts	CW	CW

*SP= Spectra Physics

☐ **Cryogen Use**

Describe type, quantity, and use

None

For all of the above systems the following procedures must be observed:

1) eye protection must be worn when working with open beams
2) laser enclosure must be interlocked

System by system breakdown:

1) Tsunami Ti:Sapphire laser:
   purpose: oscillator, seeds the regenerative amplifier, also provides light for beam diagnostics (e.g. cross correlator)

output: 0.5-1 Watt , 100 fsec pulses at 81.6 MHz, wavelength usually at 800 nm, but tunable from 700-900 nm
beam paths:

- long (~ 8 meters) folded path through pulse stretcher to seed the regenerative amplifier. Most of this is in the amplifier box. Some light will propagate through the amplifier chain even when there is no gain, so care should be taken that the beam is stopped downstream (e.g. at amplifier box exit) when using the oscillator beam alone.
- ~ 1-2 meter in open air on table 1 to Rees Spectrum analyzer
- ~ 1-2 meter in open air on table 1 to Streak Camera Trigger
- ~ 1-2 meter in open air on table 1 to Spectra Physics scanning autocorrelator
- ~ 1-2 meter in open air on table 1 to EOT photodiode for RF clock
- ~ 8-10 meter in open air on tables 1 and 2 to the scanning cross-correlator
- OTHER: remember that this laser is a frequent source of reference beams for experimental diagnostics, as well as a source for alignment when 800 nm or pulsed radiation is required. Operators should be aware of any new applications not listed here, and may inspect for new beam paths by inspecting optics chain from the laser output and looking for beams using an IR card or IR viewer.

goggles: use e.g. Kentek GBM 64
controls: 2 control modules located on shelf above the laser, pump laser control is on a stand next to the laser. Shutter control for the pump laser is above the pump laser exit aperture
hazard controls: a beam stop is located near the beam entrance to the amplifier box. This stop should be in place whenever the oscillator is not being used to drive the amplifier. A dedicated power meter is located near the Tsunami exit aperture and may be used to stop the beam going to the diagnostics. The pump laser may be shuttered or powered down when the laser is not needed for an extended time. The pump laser also has a key control.

2) Spectra Physics Millenia Nd:YVO_4 laser
purpose: to pump the Tsunami oscillator
output: 0-6 Watts green, continuous wave. Usually operates at 4-4.5 W output
beam paths: enclosed, to Tsunami pump input port
goggles: use e.g. Kentek GBM 64
controls: remote controller on stand next to laser, power supply with located on floor under table 2
hazard controls: laser cover is interlocked, power supply cuts power when room interlock is violated. Key control on power supply (usually left in place, since the laser is connected to the room interlock)

3) Spectra Physics GCR-150
purpose: to pump the regenerative amplifier and the first two-pass amplifier
output: ~300 mJ 532 nm pulsed at 10 Hz. 6-7 nsec pulses when Q-switched
beam paths: closed to amplifier box. Inside the amplifier box, open paths to the regenerative amplifier crystal and the 2-pass amplifier crystal, both approx 1.5-2 meters.
goggles: use e.g. Kentek GBM 64
controls: remote located on top of laser head. Gas purge flow control on table 1 next to the laser head. Trigger synchronizaton electronics located on shelf inside table enclosure. Power supply located outside of laser room enclosure
hazard controls: power supply prevents laser firing when room interlock is violated. Key control on power supply (usually left in place, since the laser is connected to the room interlock)

4) Spectra Physics GCR-170
purpose: to pump the second two-pass amplifier
output: 300-340 mJ 532 nm pulsed at 10 Hz. 6-7 nsec pulses when Q-switched
beam paths: enclosed to amplifier box. 1.5-2 meters open path within amplifier box to amplifier crystsl

goggles: use e.g. Kentek GBM 64
controls: remote located on top of laser head. Gas purge flow control on table 1 next to the laser head. Trigger synchronizaton electronics located on shelf inside table enclosure. Power supply located outside of laser room enclosure
hazard controls: power supply prevents laser firing when room interlock is violated. Key control on power supply (usually left in place, since the laser is connected to the room interlock)

5) Ti:Sapph CPA system (Spectra Physics TSA 50). Note that this system is essentially the combination of the above systems and the amplifier box.
purpose: provides 800 nm pulses from which photocathode and seed pulses are derived. Also provides light for experimental diagnostics
output: up to 50 mJ at 800 nm. Pulse width from 0.1-250 picoseconds
beam paths:
- **frequency tripler:** ~4 meters on table 2 through the frequency tripler for the photocathode pulse.
- **Seed Beam generation and transport:** Enclosed and open path to compressor for HGHG seed compressor. Beyond the compressor, this beam has a 10-12 meter path on table 2, followed by an enclosed ~35 meter path to the seed area in the accelerator enclosure
- **Seed area and Diagnostics inside of the accelerator enclosure**. The seed area is an enclosed optical table inside the accelerator enclosure. The enclosure is light-tight and clearly labeled with laser warning signs. Inside are optics that steer the beam into the accelerator. The seed beam may also be diverted into enclosures along the accelerator beamline for various diagnostics (e.g. electro-optic electron beam profiler, THz output profiler). These diagnostics are optically enclosed, and the enclosures are posted with laser warning signs. A helium-neon alignment laser is permanently positioned in the seed table enclosure and co-aligned with the seed beam so that the seed and these diagnostics can be safely prealigned. Note that when working on any of these applications, when access to an optical enclosure is required, the required protocol in ANSI Z136.1 and the SBMS Laser Safety subject area for laser service/repair must be observed. In this case, the accelerator enclosure will constitute the nominal hazard zone (NHZ). All unqualified personnel will be excluded from the NHZ and its entrances posted with the required “NOTICE” and “DANGER” warning signs. Observe the alignment safety principles listed below in the “Administrative Controls Description” section
- This source is also used in experimental applications, and operators should be aware of the current beam configuration.

goggles: use e.g. Kentek GBM 64
controls: output contingent on and controlled through lasers 1-4. Also compressor length control is accessible inside of the amplifier box and in the external compressor box. A power attenuator is located in the photocathode pulse leg shortly after the exit from the amplifier box.
hazard controls: output ceases on room interlock violation. Interlocked shutter for output to accelerator area. Hazard zone and postings as described in “beam paths”

6) Nonlinear Frequency Synthesis.
purpose: At present this consist only of 400 nm and 266 nm generation for the photocathode pulse. The 400 nm is dumped immediately after production.
output: 266 nm, 0.1-20 psec, up to 2 mJ
beam paths: ~10 meters open path on table 2. through spatial filter to relay input. After spatial filter, part of the beam is picked off and sent ~8 meters to a diagnostic (cross correlator). The relay path is ~13 meters long, enclosed from the room exit on.
goggles: use e.g. Kentek GBM 64
controls: phase matching control on table 2, spatial filter control on table 2, power attenuator on table 2 in first section of the relay.
hazard controls: output ceases on room interlock violation. Interlocked shutter for output to accelerator area.

7) Alignment Diode laser

purpose: alignments requiring IR light (e.g. amplifier systems, stretcher, compressors, transport optics)
output: 5 mW CW single frequency in the range 770-820 mW
beam paths: experimental, also any of the amplifier or transport paths might be aligned with this laser.
goggles: use e.g. Kentek GBM 64
controls: operator must take care to contain beam and limit open path length as much as possible. Look with viewer after each phase of alignment to check for stray beams, leakage or unintended reflections. Always use an opaque backstop at the end of the beam path.
hazard controls: protective eyewear, minimize personnel in use area.

8) Helium Neon Lasers
purpose: experimental alignments
output: up to 30 mW CW at 633 nm
beam paths: experimental, also any of the amplifier or transport paths might be aligned with a HeNe
goggles: e.g. Laser Vision L648
controls: operator must take care to contain beam and limit open path length as much as possible. Look with viewer after each phase of alignment to check for stray beams, leakage or unintended reflections. Always use an opaque backstop at the end of the beam path.
hazard controls: protective eyewear, minimize personnel in use area.

☐ **Chemicals & Compressed Gasses**

Describe type, quantity, and use.

- Compressed Nitrogen used as a purge gas, ~2 cylinders/week. Compressed gas training is required of operators
- Solvents (methanol, acetone) used for cleaning optics, kept in 1-4 liter quantities . Stored with secondary containment.
- Dessicants (silica gel or calcium carbonate) used for protecting optics in closed containers.

☐ **Electrical Hazards**

There are 3 large power supplies.

The Millenia Nd:YVO_4 power supply is powered by single phase 110VAC 60Hz line and is completely self contained. There should be no reason for the operator to open this. It contains a low voltage, high current (~75 A) supply to drive the diode laser arrays which are contained inside the supply (the diode output is transported to the laser head through fibers in the umbilical cord. No high voltage or large currents are transferred to the laser head.

The YAG lasers are each driven by Spectra Physics PS100 power supplies. These are supplied by 3 phase 220 VAC lines. these supply current pulses to the discharge lamps and high voltage to the Q-switches in the laser. When laser head covers are removed, these are an electrical hazard. Lines and contacts where these hazards exist inside the head are clearly labeled. All operators must have Electrical Safety training before working on YAG lasers. When changing filters inside the power supply, power down and unplug the power supply, and wait 5 minutes to be sure that charge on capacitors has leaked off.

☐ **Other Special Equipment**

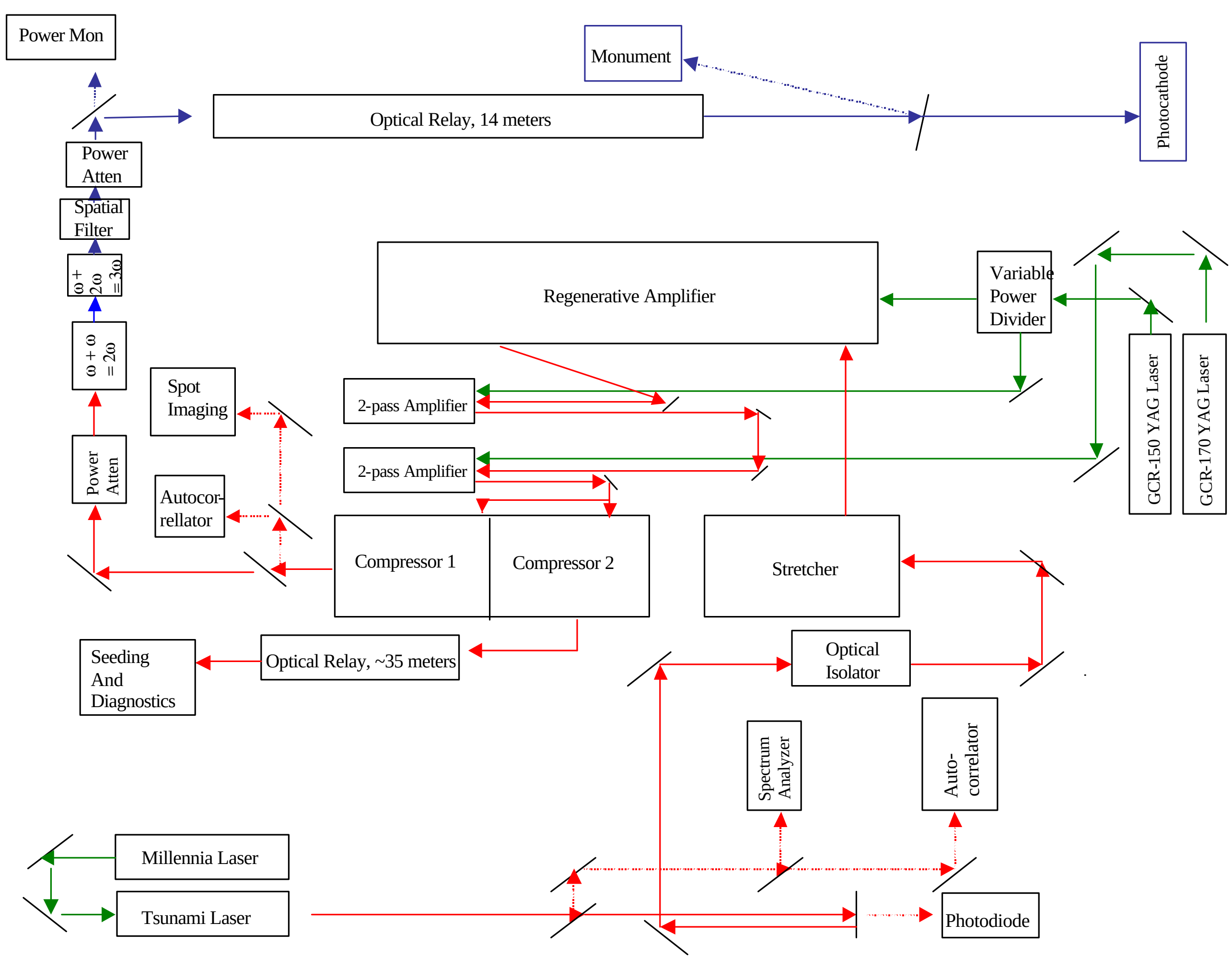
Description *(Equipment used with the laser(s)).*

Standard Diagnostic equipment: oscilloscopes, photodetectors, power meters, autocorrelators, spectrum analyzers, monochromators, streak camera, PC-based data acquisition system, cameras, monitors.

With all optical diagnostics, the operator must exercise special care when working with the optical beams inside the device, as the beams may pose a hazard when misaligned or even during normal operation (e.g. the moving reflection inside a scanning autocorrelator). Read the safety section of the device's manual and wear protective eyewear.(see charts below for proper eyewear for given wavelengths)

Laser System Configuration: Describe the system controls *(keys, switch panels, computer controls),* beam path and optics *(provide a functional/block diagram for complicated beam paths)*.

Diagram attached. The Nd:YVO_4 laser pumps the Ti:Sapphire 80 MHz oscillator, which acts as the seed for the CPA system. The seed pulse is stretched, amplified in 3 stages, and recompressed. The three stages of amplification are pumped by the two Q-switched Nd:YAG lasers. This output of the amplifiers is split, and part is frequency-tripled to provide the 266 nm drive pulse for the photocathode. This pulse is relayed through a vacuum pipe to an enclosure by the RF gun (also interlocked) and is further conditioned on an optical table there before being introduced into the gun. The remainder of the output is compressed separately and used to seed the FEL or drive diagnostics



DEVELOP CONTROLS
IDENTIFY ES&H STANDARDS

Recognition, evaluation, and control of laser hazards are governed by the following documents.

American National Standards Institute (ANSI) Standard for Safe Use of Lasers;
(ANSI Z136.1-2000)

Laser Safety Subject Area

Brookhaven National Laboratory Environment Safety and Health Standard: 1.5.3 INTERLOCK SAFETY FOR PROTECTION OF PERSONNEL

ENGINEERING CONTROLS

☒ Beam Enclosures	☒ Protective Housing Interlocks	☐ Other
☒ Beam Stop or Attenuator	☒ Key Controls	
☐ Activation Warning System	☒ Other Interlocks	
☐ Ventilation	☐ Emission Delay	

Describe each of the controls in the space provided below this text. Interlocks and alarm systems must have a design review and must be operationally tested every six months. Controls incorporated by the laser manufacturer may be referenced in the manuals for these devices. **Attach a copy of the design review documentation and a written testing protocol. Attach or keep elsewhere any completed interlock testing checklists to document the testing history.**

Engineering Controls Description:

The entire Laser system is in an interlocked room which is light-tight to the surrounding environment. The RF gun hutch, where open beams may also occur, is interlocked in the same interlock system. Lasers 2-4 also have key controls (and laser 1 operates only when laser 2 is running).

System Breakdown:

Tsunami: cover interlock; output tied to laser room interlock; amplifier box encloses the beam for seeding the amplifier; output contingent on Millenia laser output

Millenia Nd:YVO_4: beams enclosed; output tied to laser room interlock; key control on power supply (usually left in place, when security is an issue, the key is to be held by the system owner)

GCR-150 and GCR-170: beams enclosed to amplifier box; low power mode (long pulse) for alignments, IR beams are dumped; green beams dumped when not in use; output tied to laser room interlock; key control on power supplies (usually left in place, when security is an issue, the key is to be held by the system owner)

CPA system: output tied to laser room/gun hutch interlock; power attenuator located just outside of the amplifier box;

Nonlinear Frequency synthesis: output tied to laser room interlock; output shutter to accelerator area is interlocked; power attenuator for photocathode pulse located in the first section of the optical relay to the gun hutch, on table 2;

Diode and HeNe alignment lasers: no engineering controls

ADMINISTRATIVE CONTROLS

☒ Laser Controlled Area ☒ Signs ☒ Labels ☐ Operating Limits

The format and wording of laser signs and labels are mandated by BNL and ANSI standards. Only the standard signs are acceptable. Standard signs are available from the BNL Laser Safety Officer.

All lasers must have a standard label indicating the system's wavelength, power, and ANSI hazard class. Required labels must remain legible and attached. The manufacturer should label commercial systems.

Standard Operating Procedures (SOP) are required for laser system operation, alignment, and maintenance. The SOPs need only contain the steps necessary to perform these tasks and identify when and where posting and personal protective equipment is required. SOPs must be approved by the BNL Laser Safety Officer and should be kept with this program documentation.

Administrative Controls Description:

The Laser Room is posted with standard signs describing the systems within. The room is interlocked, with the standard flashing red sign when the interlock is active. To gain entry, a person must push a series of buttons and move through doors in a prescribed sequence. All lasers are labeled in accordance with the ANSI standard

When access is required to optical enclosures inside of the accelerator enclosure (seed and diagnostic enclosures. see beam paths description of system 5), the protocol in ANSI Z136.1 and the SBMS Laser subject area for laser service/repair must be followed. In this case, the accelerator enclosure will be the Nominal Hazard Zone. The established "NOTICE" and "DANGER" warning signs will be posted at the entrances to the enclosure, and unqualified personnel should be excluded from the enclosure.

Attached below are the current standard start up and alignment procedures for basic laser operations. These reflect the current state of the experiment, and are given to illustrate methods and precautions. Since the SDL is an experimental facility, the beam paths and procedures may change in their details It is the operator's responsibility to confirm the beam configuration by inspection and consulting the system owner before starting work on any section.

A few general principles of alignment safety should be stressed:

1) always wear eye protection when working with open beams.
2) make sure that reflective jewelry/badges/clothing that might intercept the beam is removed. For example, watches, rings, bracelets, pendulous necklaces. Note that ID badges should not be worn around the neck: they can drop into the beam when you lean over.
3) When aligning outside of the laser room with class II or IIIa lasers, observe all posting requirements (see sbms laser subject area) and minimize the number of other personnel in the area.
4) when aligning in the laser room, minimize the number of personnel in the area. If other qualified personnel are working in the area, inform them of the alignment, and the location of the beams you will be adjusting.
5) always align with the lowest intensity available for the job.
6) never insert reflective surfaces into the beam. When inserting an optic, block the beam upstream of the intended insertion, then secure the optic stably in the desired location and orientation, then unblock the beam. When removing an optic, block the beam upstream of the optic before removing it, and be certain of where the new beam path will be with the optic removed..

Procedure for Laser Operation

- Turn on Laser Room Interlock
  - verify room is clear of unauthorized people and warn occupants that room is being interlocked, while pressing check station buttons 1 and 2
  - exit room and press final check station button
  - wait for interlock sign to come on, press "laser power reset"
- Q-switched Nd:YAG Laser (GCR-150) Operation
  - Turn on external chiller
  - Turn on key switch.
  - Turn on gas supply.
  - verify lamp energy is set to 0 and mode selector to long pulse mode.
  - Press Enable button, raise lamp energy to maximum, and wait >30 minutes to warm up the system.
- Diode-Pumped Nd: YVO_4 Laser (Millenia) Operation
  - Press Laser Power button to begin the short warm-up cycle.
  - Wait for ~3 minutes to stabilize diode temperature. Controller will indicate progress and completion of this step
  - Press and hold the Laser Power button until laser starts. Laser power is set for 4.04W.
  - verify that beam tubes between Millenia and Tsunami are in position.
  - put on protective eyewear (e.g. Kentek GBM 64)
  - Open shutter.
- Mode-Locked Ti:sapphire Laser (Tsunami) Operation
  - Check chiller and verify the temperature is set for ~18°.
  - Turn on power meter and check output power. At 4.04W pump power, the output should be ~640mW.
  - Adjust steering pump mirror and cavity end mirror to optimize laser output.

- Press Enable button to start RF to initiate mode locking.
- Measure spectrum using Rees spectrum analyzer.
- Adjust birefringent filter micrometer to tune the central wavelength to 800nm.
- Adjust prism insertion micrometer to get spectral bandwidth of ~6-7nm (this should stay stable day-to-day).
- Confirm the alignment of the output laser beam so that it passes through all alignment apertures into regenerative amplifier.
- Block the beam from entering regenerative amplifier.

- Regenerative Amplifier Alignment

- Alignment without seed
  - Turn on oscilloscope, and DG-535.
  - Turn on Pockels cell driver, warm up for >30 minutes.
  - Reduce Nd:YAG lamp energy to 0, and remove beam stop to regenerative amplifier.
  - Raise Nd:YAG lamp energy to maximum, and check pump light passes through alignment apertures.
  - Check DELAY1 and DELAY 2 on Pockels cell driver are set to E and 10, respectively. Then set DELAY 2 to 20.
  - Turn on high voltage switch on Pockels cell driver. Regenerative amplifier should start lasing after HV comes on.
  - Q-switched envelope should be observed on the oscilloscope.
  - Put power meter at the output of regenerative amplifier to measure output power.
  - Adjust cavity end mirror to minimize buildup time and maximize the output.
- Alignment with seed
  - Set DELAY 2 back to 10.
  - Unblock the seed light. The buildup time should be reduced, and a pulse train should be observed on the oscilloscope.
  - Align seed to minimize the buildup time.
  - Adjust cavity end mirror to minimize the buildup time.

- Adjust pump waveplate so that the pulse after the peak of the buildup trace is switched out.
- Measure output power. It should be ~32mW.

- Two-pass Amplifier Alignment

(For first two-pass amplifier only. The second amplifier is bypassed)

- Alignment without seed
  - Remove power meter from the output of regenerative amplifier.
  - Block the seed from entering regenerative amplifier.
  - Set DELAY 2 to 20.
  - Use steering mirrors after regenerative amplifier to align the regenerative output p through all alignment apertures in front of the Ti:sapphire crystal.
  - insert the removable aperture. Use steering mirror behind the Ti:sapphire crystal to center the spot on the pedestal aperture. Use steering mirrors after first power amplifier to align the laser beam passes through all alignment apertures and compressor.
  - Put power meter between the two lenses of the beam expanding telescope.
- Alignment with seed
  - Reduce Nd:YAG lamp energy to 0.
  - Set DELAY 2 back to 10.
  - Unblock seed light.
  - Remove beam stop to first power amplifier.
  - Raise lamp energy to maximum.
  - Adjust the pump mirror to maximize the output power of first power amplifier.
  - Measure the power. It should be ~300-330mW.
  - Remove power meter, and double check the alignment through all alignment apertures.

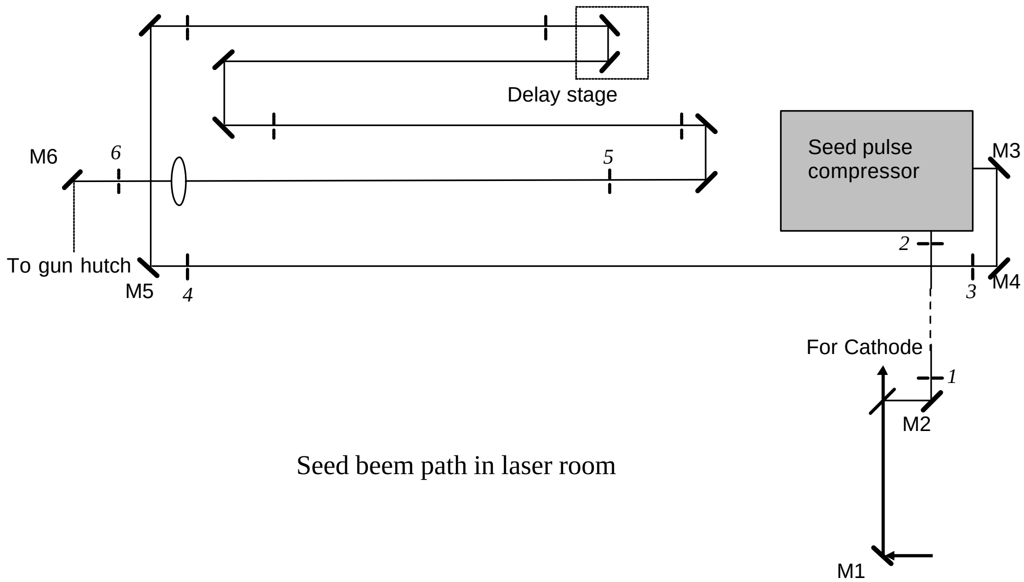
- UV Alignment
  - Turn on He-Ne laser, Molectron detector, vacuum and monitor.
  - Put power meter behind the power attenuator.

- Adjust the waveplate and obtain ~130-140 mW.
- Remove power meter. Align the laser beam passes through alignment apertures in front of BBO crystals.
- Unblock the laser beam to BBO crystals.
- Use flip mirror to steer UV beam to Moletron detector, and measure UV pulse energy.
- Optimize phase matching of two BBO crystals and maximize the UV pulse energy.1.
- Flip the flip mirror out of the beam path, and remove beam stop to the vacuum spatial filter so that UV beam can enter the vacuum spatial filter. Put a ND2 filter in UV beam path.
- Flip up the first flipper for He-Ne laser in the beam path. When using flippers, always block the beam first, flip the flipper up or down, then unblock the beam, otherwise you will be sweeping a beam through space.
- Raise the vacuum spatial filter tube and align the HeNe along the spatial filter axis, using the alignment apertures. Using the fluorescence of the UV on a business card, align it with the HeNe. .
- Block the UV beam and lower the vacuum spatial filter. Tune both vertical and horizontal micrometers of vacuum spatial filter to optimize the HeNe throughput by eye. Unblock the UV beam, it should be visible on a card at the spatial filter output. Optimize the spatial filter position for UV throughput and mode..
- Remove ND2 filter out of UV beam path. Check spatial filter adjustment.
- Flip the first flipper for He-Ne laser out of the beam path. Flip the second flipper on. Check He-Ne laser beam passes through all alignment apertures to gun hutch. Overlap UV and He-Ne light beam.
- Open laser shutter in gun hutch.
- Look at the monument monitor, and use steering mirror to align UV spot to the center of photocathode.
- Use flip mirror to steer UV light to Molectron detector and measure UV pulse energy. It should be ~50-80 uJ.

- Flip the flip mirror out of the beam path.
- Measure UV pulse shape with the cross-correlator.

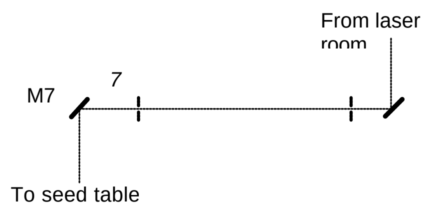
- Check for unintended relections. Close doors to the laser table enclosure

HGHG Seed Beam Alignment Procedure



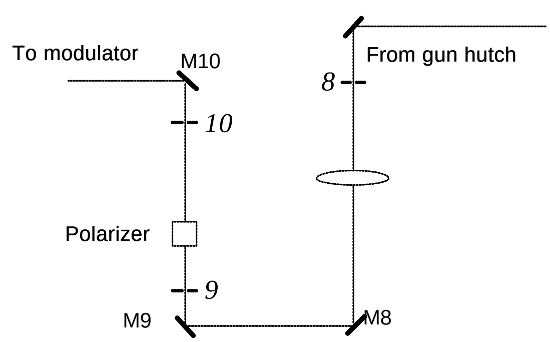
Seed beem path in laser room

1) Wear protective eyewear (e.g. Kentek GBM 64) use IR card or IR viewer to sight the beam.
2) Steering mirrors M1 and M2, align beam into compressor using apertures *1* and *2*. If the beam is aligned ready for the cathode laser compressor, this should already be aligned.
3) Steering mirrors M3 and M4, align beam to pass through apertures *3* and *4*
4) Steering mirror M5, align beam to pass through aperture *6*, the beam should now pass through apertures 5 and 6. If not, verify the beam path through the delay arm and align through apertures 5 and 6.
5) Steering mirror M6, align beam to pass through aperture *7* in the gun hutch



Seed beam path in gun hutch

6) Steering mirror M7, align beam to pass aperture *8*
7) Steering mirrors M8 and M9, align beam to pass through apertures *9* and *10*
8) Remote steering M10 to overlap seed beam and electron beam using pop15 and pop16 monitors.
9) For fine steering, step 4) to 7) can be replaced by steering M6 and watching pop 15 and pop16 monitors.



Seed beam path at

CONFIGURATION CONTROL

Prepare and attach a checklist to be used for configuration control of any protective housings, beam stops, beam enclosures, and any critical optics *(mirrors or lenses that could misdirect the beam and result in personnel hazard)*. Include entries to ensure placement of required signs and labels and status of interlock verification. Completed checklists must be posted at the laser location. The checklist does not have to be redone unless there has been a system modification, extended shutdown, or change of operations.

Safety Configuration Checklist
SDL Laser System

1. Laser Room laser hazard postings in place.
2. Laser Room Interlock and warning light operational
3. RF Gun Hutch interlock operational
4. YAG Beam Tubes Installed
5. Amplifier enclosure closed
6. Beam dumps in position:
    a. YAG beams, IR (2)
    b. YAG beams, green (4)
    c. Power attenuators for IR light (2)
    d. 400 nm & 800 nm light dump
    e. 266 nm power attenuator
7. Shutter to transport line operational
8. RF Hutch optical enclosure sealed

PERSONAL PROTECTIVE EQUIPMENT

☐ Eye Wear ☐ Skin Protection

Eye Wear: All laser protective eyewear must be clearly labeled with the optical density and wavelength for which protection is afforded. Eyewear should be stored in a designated sanitary location. Color - coding or other distinctive identification of laser protective eyewear is recommended in multi laser environments. Eyewear must be routinely checked for cleanliness and lens surface damage.
Skin Protection: For UV lasers or lasers that may generate incidental UV in excess of maximum permissible exposure (MPE), describe the nature of the hazard and the steps that will be taken to protect against the hazard.

No.	System Name							
5	**Ti:Sapp CPA system**							
1	**Spectra Physics Tsunami Ti:Sapp**							
2	**Spectra Physics Millenia Nd:YVO4**							
4	**Quanta-Ray GCR 170-10**							
3	**Quanta-Ray GCR 150-10**							
Laser & Eyewear Parameters								
	ANSI Z136.1 Class	IV	IV	IV	IV	IV	IV	IV
	Wavelength [nm]	1064	532	1064	532	532	~800	~800
	Intra-Beam OD Required							
	0.25 s		6.7		6.7	3.7		
	10 s	6.4		6.4			3.3	5.7
	600 s Diffuse Reflection	3.4	4.1	3.4	4.1	2.4	0.23	2.64
	Nominal Hazard Zone [m]	9.8	22	9.8	22	3.1	0.26	4.18

Define eyewear optical density requirements by calculation or manufacturer reference and list other factors considered for eyewear selection. The BNL Laser Safety Officer will assist with any required calculations.

1. For invisible beams, eye protection against the full beam must be worn at all times unless the beam is fully enclosed.
2. For visible beams, eye protection against the full beam must be worn at all times during gross beam alignment.
3. Where hazardous diffuse reflections are possible, eye protection with an adequate Optical Density for diffuse reflections must be worn within the nominal hazard zone at all times.
4. If you need to operate the laser without wearing eye protection against all wavelengths present, explain the precautions that will be taken to prevent eye injury.

SKIN PROTECTION:

For lasers that may generate incidental UV in excess of MPE, the operator is to minimize risk to exposure by wearing long sleeved shirts or a lab coat during laser beam alignment external to the laser housings.

Kentek GBM 64 (Orange)				SDL	Potential Sources in SDL Laser System
Glendale GPT 2233 LRQ07 (Orange)				Lasers	
Laser Vision L648 (Green)					
Wavelength [nm]	OD	OD	OD		
190-490		9+			Freq. Tripled Ti:Sapp (266 nm for Gun)
514.4		7+			
190-520			9+		Freq. Tripled Ti:Sapp (266 nm for Gun)
500-520		6+			
520-532		4+	7+	1,2,3	Green Second Harmonic from YAG, Millenium Output
633	2-3			6	He:Ne Alignment laser 632
647-676	3+				
710-750			3+		
750-780			5+		
750-850			5+		
840-920		3+			
920-1070		4+		1,2	YAG Fundamental (1064 nm)
850-1080			7+		
694-1320	7+			1,2,4,5,7	Ti:Sapp Fundamental (~800nm), Alignment Diode
10600	5+				
5000-11000		7+	7+		
			For YAG 532 line protection (*nb* GPT 2222 or 3932 equivalent)		
		Nominally for use with YAG systems			
	Nominally for use with Ti:Sapp laser system				
Laser Vision L648 are goggles with dark green lenses					
Glendale Protective technologies GPT 2233 are more like glasses with sideshields with orange lenses					
Laser Vision Goggles:		Glendale Goggles:			Kentek Goggles
UVEX Safety		Glendale Protective Technologies			KENTEK Corporation
10 Thurber Blvd		5300 Region Court			19 Depot Street
Smithfield RI 02917		Lakeland FL 33815			Pittsfield, New Hampshire 03263
800/343-4311		941/687-7266			800/432-2323

Make sure the eye protection you use is adequate for the sources of light!!!

TRAINING

LASER SAFETY TRAINING

Laser Operators must complete sufficient training to assure that they can identify and control the risks presented by the laser systems they use. Owners/Operators and Qualified Laser Operators must complete the BNL World Wide Web based training course (BNL course #HP-IND-011).

Qualified Laser Operators must also complete system-specific orientation with the system owner/operator. **System-specific training must be documented with a checklist that includes**

- Trainee name and signature
- Owner/Operator signature
- Date
- Brief list of topics covered
  - Review of this program documentation
  - Review of SOPs

All laser safety training must be repeated every two years.

MEDICAL SURVEILLANCE

Operators of ANSI Class 3b and 4 laser systems must complete a baseline medical eye examination prior to laser system operation. Any qualified ophthalmologist may complete this exam. BNL has arranged for this service from the following local physicians:

Dr. Charles Rothberg
331 East Main St.
Patchogue, NY 11772

631 758-5300
$65 per exam

The Ophthalmic Center
Dr. Basilice
3400 Nesconset Highway
East Setauket, NY 11733

631 751-2020
$60 per exam

East End Eye Associates
Dr. Sherin
669 Whiskey Road
Ridge, NY 11961

631 369-0777
$125 per exam

Personnel using physicians other than those listed must have their examination records forwarded to the BNL Occupational Medicine Clinic.

FEEDBACK AND IMPROVEMENT

Comments and suggestions for improvement should be directed to BNL-Laser Safety Officer, Chris Weilandics (X2593; weil@bnl.gov).

LASER USER QUALIFICATION

Personnel qualified to work with this laser system are listed below. These Qualified Laser Operators must understand the information and conform to the requirements contained in this document. For training and medical surveillance, enter the date of completion.

Qualified Laser Operators:

Basic Laser Training	Job-Specific Training	Medical Surveillance	Printed Name	level	Signature	Owner/Oper. Initial/date
9/12/03	9/24/03	2/ 2002	Zilu Wu	II		
5/21/03	9/24/03	6/2001	Henrik Loos	II		
10/08/02	9/24/03	11/13/03	Yuzhen Shen	II		
9/24/03	9/24/03	9/1993	Brian Sheehy	II		
10/10/03	3/25/04	10/27/03	Jonathan Neumann	I		

NSLS REVISION & PERIODIC REVIEW LOG

Document Number:	LS-SDL-0032
Subject:	Laser Safety Program Documentation: Drive and Seed Laser System for the Deep Ultraviolet Free Electron Laser (DUVFEL)

> See NSLS Quality Control Coordinator for original revision and review signatures <

REVISION TABLE

Rev	Description	Date
3	Added discussion of procedure for handling optical beams inside of the accelerator vault.	10/01/03

PERIODIC REVIEW TABLE

Complete this table to record the completion of periodic reviews for an existing controlled document. A successful periodic review will reveal the existing document is current, correct, and does not require any revision/change.

Document Review Frequency

1 year

Rev	Date	Reviewed By (Print):	Signature: